Black Body Radiation

**Purpose:** to determine investigate Black Body Radiation; in particular, to determine the Stefan-Boltzmann constant.

**Theory:** Internal energy is transferred between systems in one of three ways: Conduction, Convection, and Radiation. A body radiates energy because it is fundamentally built of charged particles and the thermal vibrations of these particles produces light and light carries energy. This is fleshed-out in Chapter 10 of Mandl. There you’ll find that the density of energy radiated by a perfect radiator (a.k.a. black body) at temperature T is \[ u(T) = \frac{4\sigma}{c} T^4 \] where \[ \sigma = \frac{\pi^2 k^4}{60h^3c^2} \] is the Stefan-Boltzmann constant. It is more common to deal with the power radiated by a body of area A, that is \[ P(T) = A \frac{c}{4} u(T) = A\sigma T^4. \]

**Experiment:** Resistively heating a black sample you can control the power it dissipates (the left hand side of the equation above), meanwhile you can measure the sample temperature (on the right hand side of the equation). Between these two (and the sample’s area) you can determine the Stephan-Boltzmann constant.

A resistive element (silicon chip) in a vacuum will be heated by passing a sequence of different current values through it. You will simultaneously monitor the sample’s current, the voltage across it, and its temperature as measured by a thermocouple attached to it. As you step through current values, you will pause at each value to allow the temperature to stabilize. At that point, the power input (I\Delta V) equals the power output (mostly \( A\sigma T^4 \)). If you plot power against temperature, you should be able to curve fit your data to determine \( \sigma \).

Note: the data will better fit a curve of the form \( T^4 + bT + c \) than just \( aT^4 \). Can you account for the other two terms?